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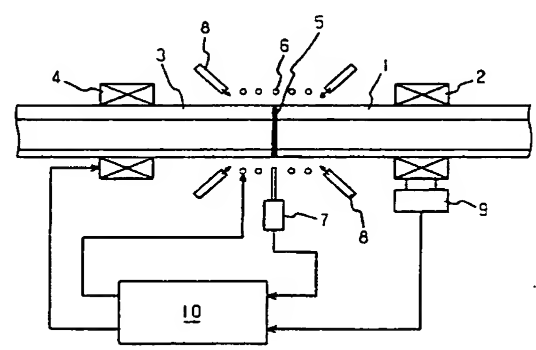
(54) Method and apparatus for bonding crossing rails

(57) A method for bonding a crossing rail includes the steps of: inserting an insert member (5) having a melting point Ti that is lower than a melting point Tb of a metal material of a crossing rail (1) made of a high manganese cast steel and a regular rail (3), in between the crossing rail (1) and the regular rail (3), and while applying a pressure to a bonding interface of the crossing rail (1) and the regular rail (3) through the insert member (5), heating the bonding portion to a temperature T to meet a relationship, Ti<T<Tb and holding the temperature T for a constant period of time to thereby bond both the rails without melting any of the rails.

Fig. 1



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Description

The present invention relates to a method and apparatus for bonding a crossing rail to be used at a switching or branching point of a railway.

In general, in many cases, a high manganese cast steel (SCMnH3: JIS-G5131) is used to crossing rails used in switching points of the rail road in view of anti-wear and shock-proof properties. Recently, in order to cope with the high speed operation of trains, there are increased demands that the high manganese cast steel cross rails and the regular rails made of carbon steel are usually bonded together to attain a one-piece structure. However, according to a conventional bonding method such as a gas pressure bonding, a Thermit welding or an enclosed welding, it would be difficult to integrate the crossing rail and the regular rails together. Accordingly, conventionally, there is only a method for mechanically fastening both the rails. The method suffers from problems that gaps or steps are formed between the rails and it would be difficult to sufficiently cope with the high speed operation of the passing trains and the improvement of the riding comfort (to reduce the vibration and noises).

In contrast, there have been attempts to integrate the crossing rails and the regular rails by the arc welding method using a welding rod made of Fe-Mn-Cr-Ni. However, an initial hardness of the welding material for the welding rod is low in comparison with that of the regular rail. In addition, a machinability thereof would be inferior in comparison with that of the high manganese cast steel. As a result, the welding material would be worn in use. It is therefore difficult to control the welding work. In this case, a crack would be likely to occur in the welded part. Thus, the conventional system suffers from various problems. It would be difficult to attain the satisfactory result.

Accordingly, in view of the foregoing defects, an object of the invention is to provide a method and apparatus for bonding a crossing rail to obtain a high bonding strength while enabling the bonding work in a short period of time without any welding crack and any degradation in material quality.

In order to attain this and other objects, according to the present invention, there is provided a method for bonding a crossing rail, characterized by comprising the steps of: inserting an insert member having a melting point Ti that is lower than a melting point Tb of a metal material having a lower melting point of a crossing rail made of a high manganese cast steel and a regular rail, in between the crossing rail and the regular rail; and while applying a pressure to a bonding interface of the crossing rail and the regular rail through the insert member, heating the bonding portion to a temperature T to meet a relationship, $Ti<T<Tb$ and holding the temperature T for a constant period of time to thereby bond both the rails without melting any of the rails.

Also, an apparatus for bonding a crossing rail used in the method for bonding the crossing rail according to the present invention is characterized by comprising a heating means for heating a bonding portion, a means for measuring a temperature of the bonding portion, a means for applying a pressure to bonding interfaces, a means for measuring the pressure, a means for causing inert gas to flow in the vicinity of the bodning portion and a means for controlling these means.

According to the bonding method of the present invention, the insert member is inserted in between the bonding interfaces of the crossing rail made of high manganese cast ~~steel crossing rails and regular rails~~. The insert material has the melting temperature Ti that is further lower than the melting temperature Tb of the metal material of the high manganese cast steel that is the basic material of the crossing rail and the metal material that is the basic material of the regualr rail. According to the present invention, while applying the bonding interfaces of both the rails through the insert material, the bonding portion thereof is heated up to the temperature T which meets the relationship, $Ti<T<Tb$ and the temperature is maintained for a predetermined period of time to thereby bond both the rails without melting the rails.

According to the present invention, it is possible to apply various heating method as the heating method of the bonding portion itself. It is preferable that the bonding portion is heated by using a high frequency wave induction heating method at a frequency of 400kHz or less or by using a direct electric heating method at a frequency of 400kHz or less. It is therefore possible to more firmly bond the two rails. In the same meaning, it is preferable that sheets or powder made of nickel alloy having a melting temperature of 1,200°C or less is used as the insert member. Also, it is preferable that the bonding conditions are that the bonding temperature T meets the relationship, $T \leq 1,300$°C, the applied pressure P to the bonding interface meets the relationship, $P \leq 1$MPa, the maintenace time S at the bonding temperature T meets the relationship, $S \geq 60$ secs, and the surface roughness Rmax of the bonding interface meets the relationship, $Rmax \leq 100 \mu m$. Also, it is preferable in the method that the bonding portion is bonded with inert gas shield.

It is also preferable according to the present invention that the bonding portion is rapidly cooled after the bonding. This is because both the rails may be more firmly bonded together. For the same purpose, it is effective that the bonding portion is heated to a temperature of 300°C or more to 450°C or less after the bonding, and the bonding portion is maintained for 0.5 hours or longer at the same temperature, and then cooled.

It is further preferable that the bonding portion is subjected to a shot-peening after the bonding. This is because both the rails may be more firmly bonded together. For the same purpose, it is also effective to apply the shot peening to the bonding portion which have been rapidly cooled after the bonding, the bonding portion which has been thermally treated after bonding, or the bonding portion which has been subjected to the heat treatment after the rapid cooling after

the bonding.

According to the present invention, the bonding portion is bonded by heating the bonding portion to the temperature T which meets the condition, Ti<T<Tb, melting the insert member and maintaining the bonding portion at the temperature. It is possible to carry out the bonding in a very narrow range without melting the metal material which is the basic material of the regular rail and the high manganese cast steel which is the basic material of the crossing rail. Accordingly, since there is no region where the hardness is low like the weld material in case where the arc welding method is used for bonding, it is possible to prevent a local wear in the weld portion. Also, since the bonding is carried out under a pressure, there is no weld crack as in the case the arc welding method is used for bonding. Furthermore, since it is possible to carry out the bonding in a short period of time in comparison with the arc weld method, it is possible to suppress the degradation of the basic material. According to the present invention, it is possible to bond the rails firmly with a high efficiency.

In the accompanying drawings:

Fig. 1 is a schematic view showing a bonding device according to the present invention; and
Fig. 2 is a schematic view showing another bonding device according to the present invention.

Fig. 1 is a schematic view showing a joint device according to the present invention. In Fig. 1, reference numeral 1 denotes crossing rails made of high manganese cast steel, numeral 2 denotes stationary chucks for gripping the crossing rails 1, numeral 3 denotes regular rail to be joined to the crossing rails 1, numeral 4 denotes movable chucks for gripping the regular rails 3, numeral 5 denotes insert member inserted between both the rails, numeral 6 denotes a high frequency wave inductive coil for heating the bonding portion of both the rails, numeral 7 denotes a radiational thermometer for detecting the temperature of the bonding portion, numeral 8 denotes a gas spray nozzle for gas-seal of the bonding portion, numeral 9 denotes a pressure gauge (load cell) provided on the stationary chucks 2 for detecting the pressure of the bonding portion applied from the regular rails 3 to the crossing rails 1, and numeral 10 denotes a controller for controlling the heat by the high frequency wave inductive coil 6 and the applied pressure by the movable chucks 4, respectively. The controller 10 is so constructed that the temperature of the bonding portion detected by the radial thermometer 7 and the pressure of the bonding portion detected by the pressure gauge 9 are fed back to be controlled to preselected values.

Fig. 2 is a schematic view showing another bonding device according to the present invention. The reference numerals which will not been explained are the same as those in Fig. 1. It should be however noted that numeral 12 denotes an AC electrode mounted on the crossing rail 1, numeral 13 denotes an AC electrode mounted on the regular rail 3, and numeral 10 denotes a controller for controlling the direct electrically generated heat through the AC electrodes 12 and 13 and the pressure applied by the movable chucks 4, respectively.

The insert member 5 is in the form of a sheet or powder made of Ni-Si-B (having a melting point of 1,050°C) or Ni-Cr-Si-B (having a melting point of 1,100°C) or the like that has a lower melting point than a melting point (1,375°C) of a high manganese cast steel which is the basic material of the crossing rail 1 and a melting point (1,470°C) of a carbon steel which is the basic material of the regular rail 3. Usually, the thickness of the insert member 5 is about 40μm. Such an insert member 5 is inserted in between joint faces of both rails and the movable chucks 4 are advanced to keep the applied pressure at 5MPa at the bonding portion. The bonding portion is heated up 1,200°C with the inductive heat of frequency of 50kHz through the inductive coil 6 or the direct electric heat of frequency of 50kHz through the AC electrodes 12 and 13 to keep its heating condition for about 90 seconds. Thus, the insert member 5 is molten and diffused into each metal structure from the bonding faces of the crossing rail 1 and the regular rail 3, thereby firmly fasten the bonding faces.

Example 1

Table 1 shows a tension test result, a fatigue test result or the like in the case where, in accordance with the embodiment of the present invention explained in conjunction with Figs. 1 and 2, a crossing rail made of high manganese cast steel (SCMnH3, melting point 1,375°C) and a regular rail made of carbon steel (melting point 1,470°C) were coupled with each other. Example 1 is a case of conventional arc welding with covered electrode, and Example 2 is a case where the insert member was not used. Also, in any example, rapid cooling was not effected after the bonding, and any thermal treatment was not effected. In Table 1, Example 1 shows a bonding by the conventional shielded metal-arc welding method, Example 2 shows a bonding made without an insert material. In each example, neither rapid cooling after bonding nor heat treatment was carried out. From Fig. 1, it is apparent that, according to the present invention, by using the insert member under the specified counditions, both the rails were firmly bonded.

Table 1

items		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
		Comparison	Comparison	Invention	Invention	Invention	Invention
insert Material	kind	-	no	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Cr-Si-B (sheet)	Ni-Si-B (powder)
	melt . temp . (°C)	-	-	1,050	1,050	1,100	1,050
heating meth. od	kind	-	induction	induction	direct current	direct-current	induction
	Fre. (Hz)	-	50k	50k	50k	50k	50k
joint surface roughness Rmx(μm)		-	40	40	40	40	40
shielding gas		-	N_2	N_2	N_2	N_2	N_2
bonding temp.(°C)		-	1,200	1,200	1,200	1,200	1,200
holding period (sec)		-	90	90	90	90	90
applied pressure (MPa)		-	5	5	5	5	5
rapid cooling of bonding portion		-	no	no	no	no	no
bonding efficiency		bad	good	good	good	good	good
tension test	tensile strength (MPa)	748	304	753	746	750	747
	elongation (%)	28	0	30	30	30	30
	fractured position	SCMnH3 basic material	bonding interface	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material
fatigue test	stress amplitude Nf at 206M Pa	$<1\times10^4$	$<1\times10^4$	$>2\times10^6$	$>2\times10^6$	$>2\times10^6$	$>2\times10^6$
	fractured position	bonding interface	bonding interface	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material
total evaluation		bad	bad	good	good	good	good

Table 2 shows a result in the case where the same bonding is effected. However, in this case, the frequency was changed in the high frequency inductive heating or direct electric heaitng. From Table 2, it will be understood that it is desirable that the frequency is less than 400kHz.

Table 2

items		Ex. 7	Ex. 8	Ex. 9	Ex. 10	Ex. 11
		Invention	Invention	Invention	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Cr-Si-B (sheet)
	melt. temp. (°C)	1,050	1,050	1,050	1,050	1,100
heating method	kind	induction	induction	induction	direct current	direct current
	Fre. (Hz)	1M	400k	100k	1M	400k
joint surface roughness Rmx(μm)		40	40	40	40	40
shielding gas		N_2	N_2	N_2	N_2	N_2
bonding temp.(°C)		1,200	1,200	1,200	1,200	1,200
holding period (sec)		90	90	90	90	90
applied pressure (MPa)		5	5	5	5	5
rapid cooling of bonding portion		no	no	no	no	no
bonding efficiency		bad	good	good	bad	good
tension test	tensile strength (MPa)	437	738	753	420	741
	elongation (%)	16	30	30	13	31
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material	bonding interface	SCMnH3 basic material
fatigue test	stress amplitude Nf at 206MPa	$2x10^5$	$>2x10^6$	$>2x10^6$	$2x10^5$	$>2x10^6$
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material	bonding interface	SCMnH3 basic material
total evaluation		medium	good	good	medium	good

Table 3 shows a result in the case where the same bonding is effected. However, in this case, the kind and melting point of the insert member and its bonding temperature were changed. From Table 3, it will be understood that it is necessary that the temperature T should satisfy the above-described condition, Ti<T<Tb.

Table 3

items		Ex. 12	Ex. 13	Ex. 14	Ex. 15	Ex. 16
		Comparison	Invention	Invention	Comparison	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Cr-Si-B (sheet)
	melt. temp. (°C)	1,250	1,200	1,100	1,050	1,100
heating method	kind	induction	induction	induction	direct current	direct current
	Fre. (Hz)	20k	20k	20k	20k	20k
joint surface roughness Rmx(μm)		40	40	40	40	40
shielding gas		N_2	N_2	N_2	N_2	N_2
bonding temp. (°C)		1,250	1,250	1,200	1,380	1,250
holding period (sec)		90	90	90	90	90
applied pressure (MPa)		5	5	5	5	5
rapid cooling of bonding portion		no	no	no	no	no
bonding efficiency		good	good	good	good	good
tension test	tensile strength (MPa)	451	743	758	384	737
	elongat ion (%)	4	30	30	2	30
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3basic material	bonding interface	SCMnH3 baisc material
fatigued test	stress amplitude Nf at 206MPa	$<3x10^4$	$>2x10^6$	$>2x10^6$	$<1x10^4$	$>2x10^6$
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3basic material	bonding interface	SCMnH3 baisc material
total evaluation		bad	good	good	bad	good

Table 4 shows a result in the case where the same bonding is effected. In this case, the bonding time was changed. In Table 4, the example 17 is an example where no maintenace time was kept.

Table 4

items		Ex. 17	Ex. 18	Ex. 19
		Comparison	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)
	melt. temp. (°C)	1,100	1,100	1,100
heating method	kind	induction	induction	induction
	Fre. (Hz)	3k	3k	3k
joint surface roughness Rmx(μm)		30	30	30
shielding gas		N_2	N_2	N_2
bonding temp. (°C)		1,200	1,200	1,200
holding period (sec)		0	60	180
applied pressure (MPa)		5	5	5
rapid cooling of bonded portion		no	no	no
bonding efficiency		good	good	good
tension test	tensile strength (MPa)	504	746	741
	elongation (%)	3	30	30
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material
fatigue test	stress amplitude Nf at 206MPa	1×10^5	$>2 \times 10^6$	$>2 \times 10^6$
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material
total evaluation		bad	good	good

Table 5 shows a result in the case where the same bonding is effected. In this case, the applied pressure in bonding was changed for bonding the rails. From Table 5, it will be understood that it is preferable that the applied pressure in bonding be not smaller than 1MPa.

Table 5

items		Ex. 20	Ex. 21	Ex. 22
		Invention	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)
	melt. temp. (°C)	1,100	1,100	1,100
heating method	kind	induction	induction	induction
	Fre. (Hz)	3k	3k	3k
joint surface roughness Rmx(μm)		30	30	30
shielding gas		N_2	N_2	N2
bonding temp. (°C)		1,200	1,200	1,200
holding period (sec)		180	180	120
applied pressure (MPa)		0.5	1	10
rapid cooling of bonded portion		no	no	no
bonding efficiency		good	good	good
tension test	tensile strength (MPa)	660	738	745
	elongation (%)	9	30	30
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material
fatigue test	stress amplitude Nf at 206MPa	$1x10^6$	$>2x10^6$	$>2x10^6$
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material
total evaluation		medium	good	good

Table 6 shows a result in the case where the same bonding is effected. In this case, the surface roughness Rmax of the bonding face in the crossing rail and the regular rail were changed. From Table 6, it will be understood that the surface roughness Rmax of the bonding surface be not greater than 100μm.

Table 6

items		Ex. 23	Ex. 24	Ex. 25
		Invention	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)
	melt. temp. (°C)	1,100	1,100	1,100
heating method	kind	induction	induction	induction
	Fre. (Hz)	3k	3k	3k
joint surface roughness Rmx(μm)		150	100	10
shielding gas		N_2	N_2	N_2
bonding temp. (°C)		1,200	1,200	1,200
holding period (sec)		90	90	90
applied pressure (MPa)		7	7	7
rapid cooling of bonded portion		no	no	no
bonding efficiency		good	good	good
tension test	tensile strength (MPa)	581	741	752
	elongation (%)	14	30	30
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material
fatigue test	stress amplitude Nf at 206MPa	$8x10^4$	$>2x10^6$	$>2x10^6$
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material
total evaluation		medium	good	good

Table 7 shows a result in the case where the same bonding is effected. In this case, the shielding gas in bonding was changed. From Table 7, it will be understood that it is desirable that the bonding portion is shielded by inert gas shielding in bonding.

Table 7

items		Ex. 26	Ex. 27	Ex. 28	Ex. 29
		Invention	Invention	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)
	melt. temp. (°C)	1,100	1,100	1,100	1,100
heating method	kind	direct current	direct current	direct current	direct current
	Fre. (Hz)	10k	10k	10k	10k
joint surface roughness Rmx(μm)		30	30	30	30
shielding gas		no	Ar	He	N_2
bonding temp.(°C)		1,200	1,200	1,200	1,200
holding period (sec)		120	120	120	120
applied pressure (MPa)		5	5	5	5
rapid cooling of bonded portion		no	no	no	no
bonding efficiency		good	good	good	good
tension test	tensile strength (MPa)	419	750	748	746
	elongation (%)	12	30	30	30
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material
fatigue test	stress amplitude Nf at 206MPa	2×10^5	$>2 \times 10^6$	$>2 \times 10^6$	$>2 \times 10^6$
	fractured position	bonding interface	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material
total evaluation		medium	good	good	good

Table 8 shows a result in the case where the same bonding is effected. In these Examples, the bonding portion was water-cooled rapidly after the bonding. And then, in Examples 31~34, the bonding portion was subjected to heat treatment after this water-cooling. In this heat treatment, the cooling was carried out by air-cooling. From Table 8, it is preferable that the heat treatment is effected after the rapid cooling and it will be understood that it is preferable that the heat treatment be effected for reheating at 300 to 450°C and the temperature be kept for 0.5 hours or longer.

Table 8

items		Ex. 30	Ex. 31	Ex. 32	Ex. 33	Ex. 34
		Invention	Invention	Invention	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)
	melt. temp. (°C)	1,050	1,050	1,050	1,050	1,050
heating method	kind	induction	induction	induction	induction	induction
	Fre. (Hz)	3k	3k	3k	3k	3k
joint surface roughness Rmx(μm)		30	30	30	30	30
shielding gas		N_2	N_2	N_2	N_2	N_2
bonding temp. (°C)		1,200	1,200	1,200	1,200	1,200
holding period (sec)		90	90	90	90	90
applied pressure (MPa)		5	5	5	5	5
rapid cooling of bonded portion		yes	yes	yes	yes	yes
bonding interface heat treatment		no	300°Cx0 .5h	350°Cx0 .5h	450°Cx 1h	500°Cx 2h
bonding efficiency		good	good	good	good	good
tension test	tensile strength (MPa)	784	761	758	747	659
	elongation (%)	33	31	31	32	20
	fractured position	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material	bonding interface
fatigue test	stress amplitude Nf at 206MPa	$>4x10^6$	$>2x10^6$	$>3x10^6$	$>3x10^6$	$>1x10^6$
	fractured position	SCMnH3 basic material	SCMnH3 basic material	SCMnh3 basic material	SCMnH3 basic material	bonding interface
total evaluation		good	good	good	good	medium

Table 9 shows a result in the case where the same bonding was effected. However, in this case, the bonding portion was rapidly cooled with water after bonding, and further examples 36 to 39 were subjected to shot-peening. In examples 37 and 39 among these examples, the shot-peening was effected after the heat treatment (reheating to 350°C, holding at the same temperature for one hour, and air cooling). From Table 9, it will be understood that it is preferable to effect the shot-peening of the bonding portion after the bonding, and more preferably to effect the shot-peening after the heat treatment.

Table 9

items		Ex. 35	Ex. 36	Ex. 37	Ex. 38	Ex. 39
		Invention	Invention	Invention	Invention	Invention
insert	kind	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)	Ni-Si-B (sheet)
	melt. temp. (°C)	1,050	1,050	1,050	1,050	1,050
heating method	kind	induction	induction	induction	induction	induction
	Fre. (Hz)	3k	3k	3k	3k	3k
joint surface roughness Rmx(μm)		30	30	30	30	30
shielding gas		N_2	N_2	N_2	N_2	N_2
bonding temp. (°C)		1,200	1,200	1,200	1,200	1,200
holding period (sec)		120	120	120	120	120
applied pressure (MPa)		10	10	10	10	10
rapid cooling of bonded portion		yes	yes	yes	yes	yes
bonding interface heat treatment		no	no	350°Cx1 h	no	350°Cx 1h
shot-peening arc height (mmA)		no	0.9	1.0	1.3	2.0
bonding efficiency		good	good	good	good	good
fatigue test	stress amplitude Nf at 225MPa	$2.0x10^6$	$2.2x10^6$	$2.8x10^6$	$3.2x10^6$	$3.8x10^6$
	fractured position	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material	SCMnH3 basic material
total evaluation		good	good	good	good	good

As described above, according to the present invention, the crossing rail made of high manganese cast steel and the regular rail may be bonded together in a short time, and it is possible to carry out the bonding without melting the bonding faces of both rail faces. Accordingly, there is advantage that any weld crack or any material quality degradation like the arc welding would not be caused.

Various details of the invention may be changed without departing from its spirit nor its scope. Furthermore, the foregoing description of the embodiments according to the present invention is provided for the purpose of illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

Claims

1. A method for bonding a crossing rail (1), characterized by comprising the steps of:

   inserting an insert member (5) having a melting point Ti that is lower than a melting point Tb of a metal material having a lower melting point of a crossing rail (1) made of a high manganese cast steel and a regular rail (3), in between said crossing rail (1) and said regular rail (3); and

   while applying a pressure to a bonding interface of said crossing rail (1) and said regular rail (3) through said insert member (5), heating the bonding portion to a temperature T to meet a relationship Ti<T<Tb and holding the temperature T for a constant period of time to thereby bond both the rails without melting any of the rails.

2. A method as claimed in claim 1, characterized in that the bonding portion is heated by using a high frequency wave induction heating method at a frequency of 400kHz or lower.

3. A method as claimed in claim 1, characterized in that the bonding portion is heated by using a direct electric heating method at a frequency of 400 kHz or lower.

4. A method as claimed in any of claims 1 to 3, characterized in that a sheet or powder made of nickel alloy having a melting temperature of 1,200°C or lower is used as the insert member (5)

5. A method as claimed in any of claims 1 to 4, characterized in that the bonding conditions are that the bonding temperature T meets the relationship $T \leq 1{,}300°C$, the applied pressure P to the bonding interface meets the relationship $P \geq 1MPa$, the holding time S at the bonding temperature T meets the relationship $S \geq 60$ secs, and the surface roughness Rmax of the bonding interface meets the relationship $Rmax \leq 100 \mu m$.

6. A method as claimed in any of claims 1 to 5, characterized in that the bonding portion is bonded with inert gas shielding.

7. A method as claimed in any of claims 1 to 6, characterized in that the bonding portion is rapidly cooled after the bonding.

8. A method as claimed in any of claims 1 to 6, characterized in that the bonding portion is heated to a temperature in the range of 300°C to 450°C after the bonding, and the bonding portion is maintained for 0.5 hours or longer at the same temperature, and then cooled.

9. A method as claimed in claim 7, characterized in that the bonding portion is heated to a temperature in the range of 300°C to 450°C after the rapid cooling, and the bonding portion is maintained for 0.5 hours or more at the same temperature, and then cooled.

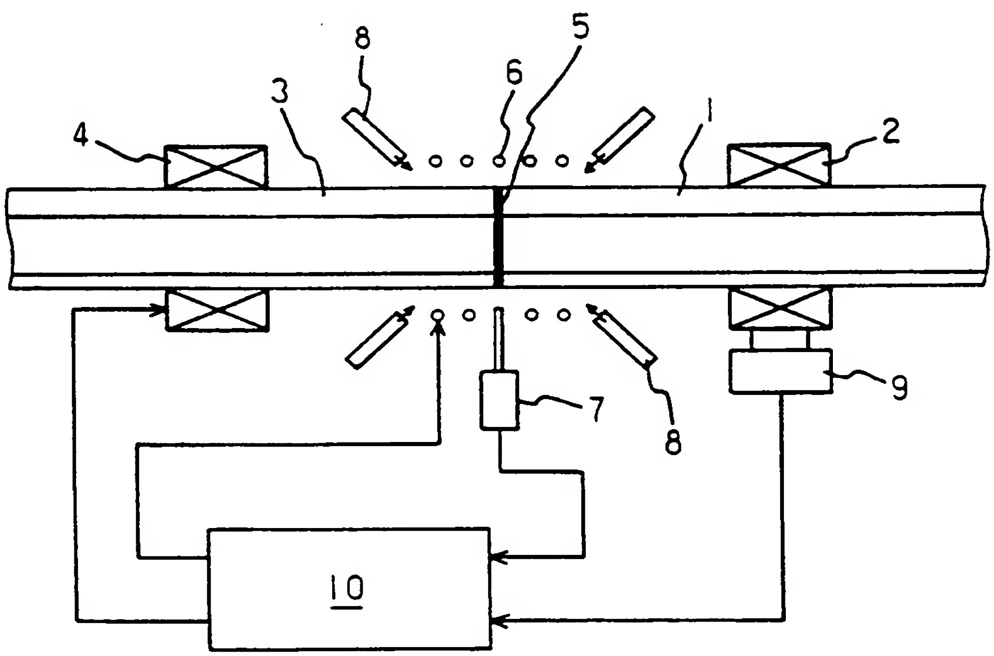
10. A method as claimed in any of claims 1 to 6, characterized in that the bonding portion is subjected to a shot-peening after the bonding.

11. A method as claimed in claim 7, characterized in that the bonding portion is subjected to a shot-peering after the rapid cooling.

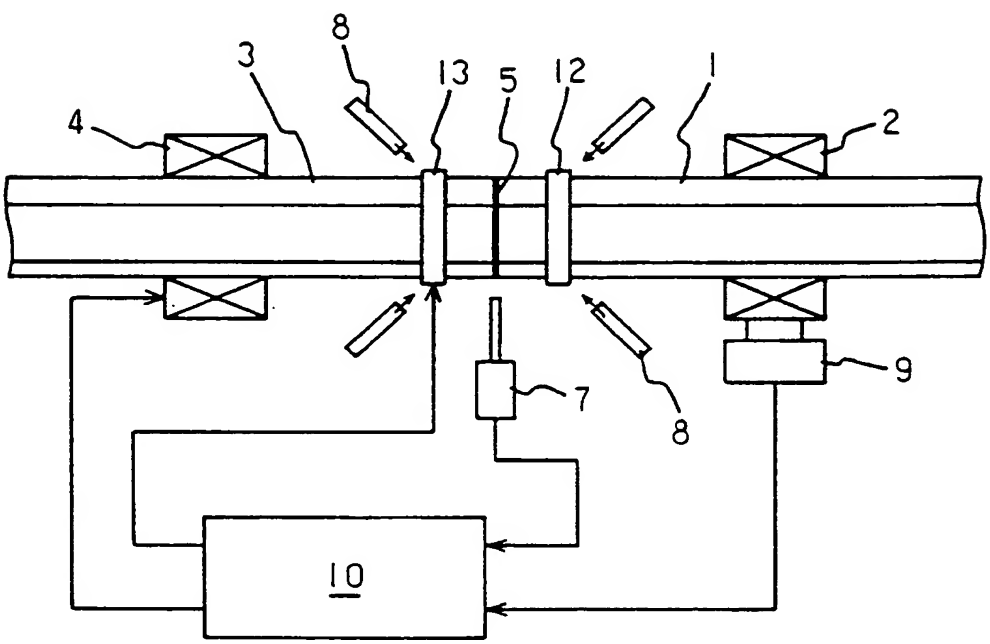
12. A method as claimed in claim 8 or 9, characterized in that the bonding portion is subjected to a shot-peening after the cooling.

13. Apparatus for bonding a crossing rail (1), for use in the method for bonding a crossing rail according to claim 1, characterized by comprising heating means (6; 12, 13) for heating a bonding portion, means (7) for measuring the temperature of the bonding portion, means (2, 4) for applying a pressure to bonding interfaces, means (9) for measuring the pressure, means (8) for causing inert gas to flow in the vicinity of the bonding portion, and means (10) for controlling these means.

Fig. 1



F i g. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2990

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 602 729 A (ALLEN EDGAR ENG ;BRITISH RAILWAYS BOARD (GB)) 22 June 1994 ---	1	B23K35/00 B23K11/02 E01B11/00 E01B11/50
A	FR 2 471 831 A (THYSSEN INDUSTRIE) 26 June 1981 ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 232 (M-1256), 28 May 1992 & JP 04 046686 A (KOMATSU LTD;OTHERS: 01), 17 February 1992, * abstract * ---	1	
A	GB 2 126 511 A (MEDAR INC) 28 March 1984 * figure 1 * -----	13	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B23K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	9 August 1996	Concannon, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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